A new method and package is provided for the mounting of semiconductor devices that have been provided with small-pitch Input/Output interconnect bumps. Fine pitch solder bumps, consisting of pillar metal and a solder bump, are applied directly to the I/O pads of the semiconductor device, the device is then flip-chip bonded to a substrate. Dummy bumps may be provided for cases where the I/O pads of the device are arranged such that additional mechanical support for the device is required.

Claim rejections - 35 U.S.C. § 103(a)

Reconsideration of the rejection of claims 13-16 and 18-24 under 35 U.S.C 103(a) as being unpatentable over Yamai (JP 409045691) in combination with Anonymous (RD 291011) and Applicant's Admitted Prior Art (AAPA) is respectfully requested based on the following.

The AAPA addresses, referring to Fig. 1, a typical flip chip package with the semiconductor device being encapsulated in a molding compound. The semiconductor device is placed on the surface of a BGA substrate, an (optional) interconnect substrate can be provided for additional routing of the electrical network to which the device is attached. The contact balls are connected

to the lower surface of the substrate for purposes of making contact with surrounding circuitry. Some prior art applications still used wire bond connections in order to achieve optimum electrical performance of the device package.

Further shown in the cross section of Fig. 1 is a re-distribution layer which provides interconnect lines over the surface of the semiconductor device and is required in prior art applications if solder bumps are required on current pad layout for wire bonding purposes. The main purpose of the redistribution layer, Fig. 1, is to reduce the pitch of solder bump interconnects, the invention removes in this manner the need for the redistribution layer.

Fig. 2 shows a cross section of a conventional BGA package whereby the semiconductor device 10 is provided with an underfill.

Figs. 1 and 2 therefore do not address key aspects of the package of the instant invention, the specification that the semiconductor devices is provided with fine-pitch solder bumps over the surface thereof. By applying fine pitch solder bumps directly to the I/O pads of a semiconductor device, aspects that have not been addressed under the AAPA, the instant invention:

- enables that a redistribution interface is no longer needed, allowing for bonding the semiconductor device directly to a Ball Grid Array substrate using the flip-chip bonding approach
- provides for shortening the interconnection between a semiconductor device and the substrate on which the device is mounted, thus improving the electrical performance of the device
- further provides for the elimination of conventional methods of re-distribution of device I/O interconnect, making packaging of the device more cost-effective and eliminating performance degradation
- further provides for improved chip accessibility during testing of the device, thus eliminating the need for special test fixtures
- further provides for improvements in performance and device reliability of BGA packages that are used for the mounting of semiconductor devices having small-pitch I/O interconnect bumps, and
- further provides for a method of mounting small-pitch semiconductor devices in such a manner that flux removal and the dispensing of device encapsulants is improved.

Yamai does, as best can be determined, not provide for an array of fine pitch solder bumps. Yamai provides for a "large-diameter" pillar shaped part and a "small-diameter pillar-shaped part". However the final pillar shaped interconnects that are provided by Yamai, Fig. 6b, have no correspondence or similarity with the cross section or the composition of the solder bumps of the instant invention as shown in Figs. 3 and 4 of the instant invention. The instant invention is based as an application of the solder balls that are shown in cross section in Figs. 3 and 4 of the instant invention.

These solder bumps, as stated on page 13 of the specification of the instant invention, provide:

- a fine-pitch solder bump
- smaller solder bumps
- a fine-pitch solder bump of high reliability due to the increased height of the solder bump
- a cost-effective solder bump by using standard solder material and eliminating the need for expensive "low-α solder"
- a solder bump that allows easy cleaning of flux after the process of flip chip assembly and before the process of underfill and encapsulation, and

- a solder bump which allows easy application of underfill.

The structure of the solder bump that is provided by Yamai, as best can be determined, also does not provide for the structure that is applied by the instant invention of the solder bump that:

- is created over a semiconductor surface such as the surface of a substrate
- comprises a layer of dielectric that has been deposited over the semiconductor surface
- comprises contact pads that have been created on the surface of a layer of dielectric
- comprises a patterned layer of passivation deposited over the surface of the layer of dielectric
- comprises an isotropically etched layer of barrier metal, completely removing the barrier metal from the surface of the layer of passivation except where the barrier metal is covered by the overlying pillar metal of the solder bump, and
- comprises a layer of under bump metal created overlying the pillar metal of the solder bump

By anisotropically etching the layer of barrier metal, Fig. 4 of the instant invention, the barrier layer protrudes from the pillar metal of the solder bump.

The cross section shown by Yamai does not show a complete semiconductor package with for instance, Fig. 5 of the instant invention, contact balls 58, underfill 62 (Fig. 6), molding compound 60 into which the device 50 is embedded for protection against the environment.

Yamai does not show a solder mask for the same reasons as cited above, that is Yamai does not show a semiconductor flip chip device package but merely provides a solder bump for a chip component and it manufacture. Yamai therefore does not provide for creating a semiconductor package whereby small pitch solder bumps are provided over a semiconductor device and whereby the package is created making optimum use of the small pitch solder bumps of the device.

Yamai does also not provide for, as specified in claim 13 of the instant invention:

- a Ball Grid Array substrate having been provided with points of electrical contact over a first and a second surface thereof, the points of electrical contact provided over the

second surface of the BGA substrate being connected to interconnect lines provided over the second surface of the BGA substrate

- a solder mask provided over the second surface of the BGA substrate
- a device being positioned over the second surface of the BGA substrate, fine pitch, high reliability solder bumps facing the second surface of the BGA substrate, providing contact between the fine pitch, high reliability solder bumps and the points of electrical contact provided over the second surface of the BGA substrate
- electrical contact having been established between the fine pitch, high reliability solder bumps and the points of electrical contact provided over the second surface of the BGA substrate by a process of solder reflow
- the semiconductor device being encapsulated in a molding compound, the molding compound surrounding the device on all sides including the active surface of the device, and
- the contact balls making electrical contact with the points of electrical contact provided over the first surface of the contact having been established between the solder balls inserted into the solder mask provided over the first surface of the BGA substrate and the points of electrical contact

provided over the first surface of the BGA substrate by a process of solder reflow.

Significantly, the difference between Yamai and the instant invention becomes even more pronounced in the supporting claims of the instant invention, which further highlight the advantages gained with the package of the instant invention, a package that uses fine-pitched solder bumps, which enables:

- claim 14, the solder mask provided over the second surface of said BGA substrate being removed from points of electrical contact provided over the second surface of the BGA substrate by a measurable amount, creating a channel through which cleaning solution can readily flow
- claim 15, the points of electrical contact provided in an active surface of the semiconductor device comprising a peripheral pad design.
- Claim 16, the points of electrical contact provided in an active surface of the device comprising a center type pad design
- Claim 17, dummy solder bumps having been provided over the active surface of the device, providing mechanical support for the device, the dummy solder bumps being provided in addition to the fine pitch, high reliability solder bumps

provided to the points of electrical contact in the active surface of the device.

Anonymous (RD 291011) provides a solder ball of an increased height so that thermal stress expansion between the chip and the substrate is reduced. Anonymous therefore does not provide a semiconductor BGA package and, most significantly, does not address advantages of packaging flip chip devices over the surface of which small pitch solder bumps have been provided. The use of a solder dam by Anonymous does not equate the Anonymous invention with the instant invention since a solder mask is more often and by necessity provided in order to complete a semiconductor device package. This aspect of the instant invention is not a critical aspect as has been argued in detail above. The solder mask is required in order to correctly interconnect the package of the invention, the fine pitch aspects of the solder bumps and the unique semiconductor package of the invention is what makes the instant invention patentable.

The relative merits of the AAPA with respect to the instant invention has been argued above and do not need to be repeated at this time.

With respect to claim 14, 15 and 16, the fine pitch solder bumps that are applied as part of the invention enable the arrangement of the solder mask in the manner specified, enabling the creation of a channel within the solder mask so that cleaning solution can flow there-through. The peripheral and center type pad design (claims 15, 16) of the electrical contacts are special design aspects of the instant invention that add design flexibility, providing for added package capabilities that may be advantageously applied for unique design requirements and implementations. For these reasons claims 14-16 are provided, providing unique and added packaging capabilities.

With respect to claims 19, 20 and 22, these claims specify further detail of creation of the package of the invention, detail that is required in order to accurately and completely make use of the unique aspects of the high-density package of the invention. The removal of the barrier layer is important in creating the solder bumps that form the small pitch solder bumps used by the package of the invention. This barrier material can be removed so that only the barrier layer that is covered by the pillar remains in place (claim 19) or so that additional barrier layer remains in place surrounding the pillar (claim 20). In creating the package of the invention, it is further important

to specify the step of removing flux from the surface of the BGA substrate, as specified in claim 22.

Regarding claims 21 and 24, these claims go to the very essence of the invention and to the solder bumps that support and are an integral part of the package of the invention. Without these claims 21 and 24, any solder bump could be used, without specifically providing detail of the pitch and the height of the solder bump on which the package of the invention is critically based.

Regarding claim 17, Pao et al. uses, Fig. 4, a standoff that is created by applying reflow to solder paste 12. The standoff encapsulates a solder ball 18, whereby the reflow of solder paste 12 must be carefully temperature controlled to assure that solder ball 18 does not simultaneously reflow with the solder paste 12. Solder paste 12 wets and overlies a bond pad 16. Solder ball 18 and adjacent solder paste 12 are shapes that have no commonality in cross section after these two elements have been formed, the solder ball 18 having a circular cross section while supporting paste 12 has a compound, platform shaped cross section. The dummy solder bumps of the invention, as specified in claim 17, are in accordance with the specification of claim 17, solder balls "being provided in

addition to said fine pitch, high reliability solder bumps provided to said points of electrical contact in the active surface of said device". The dummy solder bumps of the instant invention are therefore solder bumps that by design are not actively used as interconnects. From the cross section shown by Pao et al., Fig. 4, there cannot be derived a concept of solder bump pitch since solder ball 18 is the only solder ball in the configuration and therefore not adjacent to any other solder balls, therefore does not have a pitch. In addition and as best can be determined, Pao et al. does not concern himself with fine pitch solder balls and makes no mention thereof in the specification.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 13-16 and 18-24 under 35 U.S.C 103(a) as being unpatentable over Yamai (JP 409045691) in combination with Anonymous (RD 291011) and Applicant's Admitted Prior Art (AAPA), be withdrawn.

Other Considerations

No new independent or dependent claims have been written as a result of this office action, no new charges are therefore incurred due to this office action.

SUMMARY

A new method and package is provided for the mounting of semiconductor devices that have been provided with small-pitch Input/Output interconnect bumps. Fine pitch solder bumps, consisting of pillar metal and a solder bump, are applied directly to the I/O pads of the semiconductor device, the device is then flip-chip bonded to a substrate. Dummy bumps may be provided for cases where the I/O pads of the device are arranged such that additional mechanical support for the device is required.

It is requested that should Examiner not find the claims to be allowable that he call the undersigned Attorney at his convenience at 845-452-5863 to overcome any problems preventing allowance.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned:

"Version with markings to show changes made."

Respectfully submitted,

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